NORM risk assessment for the Søve mining complex, Norway.

Brown, J.E[1], Liland, A[1], O'Brien, R.[2] and Mora, J.C.[3]

[1] Norwegian Radiation Protection Authority, Norway
[2] Australian Radiation Protection & Nuclear Safety Agency, Australia
[3] CIEMAT, Spain

The Søve site is a disused mining complex in Telemark County, Norway, and has previously been identified as a radiological hazard. The area exhibits enhanced levels of naturally occurring radionuclides from the ^{238}U and ^{232}Th decay series. Although some remediation work was conducted following the closure of the mine in the mid 1960s, waste, primarily in the form of clustered lumps of processed material, has become mixed in surface layers over time. Limited dose-rate measurements in air have been made and the site has been mapped by aerial gamma ray surveys. This has allowed some initial estimates concerning the range and maximal dose-rates in air to be specified and a calculation of ambient dose equivalents for the public to be carried out. However, a radiation risk assessment methodology was not rigorously applied; nor have the long-term consequences of remediation options in relation to radionuclide contamination been explored. This was the reason for fixing, as the objective of this work, the application and test of the nascent General Assessment Methodology Process ('GAMP'), currently under development within WG 2 'Reference approaches to Modelling for Management and Remediation at NORM and Legacy Sites' of IAEA's EMRAS II programme, at the Søve site.

The initial part of the GAMP involves problem identification, site characterisation, screening criteria (reference levels) definition and screening assessment. At Søve, all of these stages have been completed through reference to national regulations and numeric criteria fixed by the authority. Radiological hazards have been identified at the site and the dominant exposure pathways have been determined as being those related to external exposure and inhalation of ^{222}Rn exhaled from the contaminated material.

The a priori fixed screening criteria (in terms of activity concentration) were exceeded in the scenario, precipitating the requirement to undertake a more detailed assessment for the site. The USDOE's RESRAD-Offsite code was employed to investigate potential changes in activity concentrations in various environmental compartments over time and the contribution of various exposure pathways to effective doses. Although a rigorous validation for the model was not possible, the simulation results identified external exposure from contamination in surface soils as a dominant pathway, and the dose-rates estimated for this pathway (for the initial period) corresponded quite closely with the direct dose rate measurements and human effective dose estimates derived from field measurements. Owing to problems associated with model parameterisation and results interpretation, an alternative approach was

also employed through the development of a simple leaching and groundwater migration compartmental model. This allowed activity concentrations in three waste compartments to be calculated with time. Furthermore, a published external dose-rate model that correlates information on activity concentrations with depth in soil to dose rates in air above ground has been used to estimate prospective external dose-rates to humans and evaluate the efficacy of applying various remediation options.